U.S. Department of Transportation
National Highway Traffic Safety Administration

Memorandum

107500

Subject: Submittal of Meeting Materials of the Truck and Bus Event Data Recorder Meeting to Docket No. NHTSA-2000-7699 — 1

Date: AUG 9 2000

From: Raymond P. Owings, Ph.D.
Associate Administrator for Research and Development

Reply to Attn. of:

To: The Docket

Through: Frank Seales, Jr.
Chief Counsel

On June 8, 2000, NHTSA Research and Development held a planning meeting to determine if there was sufficient support to initiate a new working group on Truck and Bus Event Data Recorders. At the end of the meeting it was decided that the working group would be formed. This memo transmits the materials circulated during the meeting for placement in the docket.

Research and Development recommends that these materials be placed in the public docket titled **Truck and Bus Event Data Recorder Working Group**.

Attachment

AGENDA NHTSA-2000-7699

Courtyard by Marriott, 1671 West Nursery Road, Linthicum, MD [redacted]
June 8, 2000

1 - Objectives/Goals of this group
  a - Limitations of NHTSA's role
  b - Public notification of meeting findings
  c - Documentation via a public final report
2 - NTSB's recommendations (see attached for summary)
  a - Require EDRs on Motor Coaches
  b - Develop standards for EDRs
3 - Estimate of time line of significant events

SUMMARY OF NTSB RECOMMENDATIONS

H-99-53

Vehicles: School buses and motorcoaches
Effective Date: Manufactured after January 1, 2003
System Requirements: The on-board recording system should record data at a sampling rate that is sufficient to define vehicle dynamics and should be capable of preserving data in the event of a vehicle crash or an electrical power loss. In addition, the on-board recording system should be mounted to the bus body, not the chassis, to ensure that the data necessary for defining bus body motion are recorded.
Data Channels/Parameters:
lateral acceleration
longitudinal acceleration
vertical acceleration
heading
vehicle speed
engine speed
driver's seat belt status
braking input
steering input
gear selection
turn signal status (left/right)
brake light status (on/off)
head/tail light status (on/off)
passenger door status (open/closed)
emergency door status (open/closed)
hazard light status (on/off)
brake system status (normal/warning)
flashing red light status (on/off) (school buses only)
status of additional seat belts
airbag deployment criteria
airbag deployment time

airbag deployment energy

H-99-54

EDR Standards:

parameters to be recorded
data sampling rates
duration of recording
interface configurations
data storage format
incorporation of fleet management tools
fluid immersion survivability
impact shock survivability
crush and penetration survivability
fire survivability
independent power supply
future requirements and technological advances

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SafeTRAC™ Technical Brief

Overview

SafeTRAC is a vision-based lane tracking system based on a patented algorithm developed jointly by AssistWare Technology, Inc. and Carnegie Mellon University under USDOT sponsorship. SafeTRAC offers a unique combination of preemptive drowsy driver detection and instantaneous lane departure warning. It measures the vehicle's position in the lane using images of the road ahead from a small video camera. If the vehicle begins to weave excessively or drift off the road, SafeTRAC triggers an audible alarm. SafeTRAC has undergone over 150,000 miles of on-road testing in cars, trucks, and buses as part of our internal and customers tests. It can operate effectively in over 97% of all highway driving conditions, and gives false alarms less than once every 8 hours of driving.

Competitive Advantages

We believe that the technology embodied in SafeTRAC is superior to all other systems worldwide. The system has several unique characteristics that make it robust and reliable across weather and road conditions, and position it for widespread acceptance within the trucking community:

- SafeTRAC uses a sophisticated, adaptive algorithm for road feature tracking. As a result, SafeTRAC can track lane markings in conditions where the competition cannot (low sun angle, worn markings, rain or snow on the road, etc.). In addition, unlike the competition, SafeTRAC can operate effectively even when lane markings are entirely missing. If painted lane markings aren't available, SafeTRAC will track more subtle features, like oil drops down the lane center, occasional small retro-reflectors, even just tracks left in the snow by previous vehicles. This is particularly important in the US, where roads are often not consistently marked or maintained. (See Figures 1-6)
- SafeTRAC's CCD camera is far superior to the CMOS cameras typically used by the competition. This advantage is particularly apparent in low light conditions.
- SafeTRAC provides lane departure warnings, real-time driver alertness feedback and drowsy driver warnings. The competition provides only lane departure warnings. SafeTRAC's alertness feedback and drowsy driver warnings utilize a proprietary, adaptive algorithm to gauge the driver's state.
- SafeTRAC uses a very sophisticated warning algorithm to minimize false alarms. The competition does not.
- SafeTRAC's operation is easily adjusted through a simple driver interface. The operation of competing systems is typically not adjustable by the driver. For example, the competing systems are typically configured to always trigger a warning the moment the vehicle's tire crosses the lane. In contrast, SafeTRAC's threshold can be adjusted to trigger before or after the tire crosses the lane. This is particularly important for trucks, which are much wider than passenger vehicles.
- SafeTRAC is very easy to install and calibrate on all types of vehicles. A typical aftermarket installation takes less than 10 minutes. System calibration is automatic and takes less than 30 seconds.
- SafeTRAC has built in video and data logging facilities, for "black box" accident reconstruction and/or driver monitoring (important for commercial fleets).

Road and Weather Conditions

We and our customers have conducted about 150,000 miles of testing with the SafeTRAC, on all types of road and in all weather and lighting conditions. (The majority of the testing has been done in the U.S., but we have also verified system operation in Japan and Germany.) The system's availability (percent of the time the system is tracking the lane correctly and ready to warn) is over 97%. False alarms occur about once every 8 hours. As one example, on a recent interstate trip of about 350 miles, the system was available 99.45% of the trip, giving no false alarms and missing no lane departures.

Shadows, sunlight, rain and snow are typically not a problem. The one combination of conditions that can cause problems is nighttime rain, when glare from headlights or overhead streetlights can make it difficult to see road features. In this condition, the system determines that it is unable to reliably track the road, provides an audible indication of this to the driver, and then temporarily suppresses warnings until the situation clears up. The figures below show a few of the conditions that SafeTRAC can handle.

Figure 1: Typical U.S. interstate

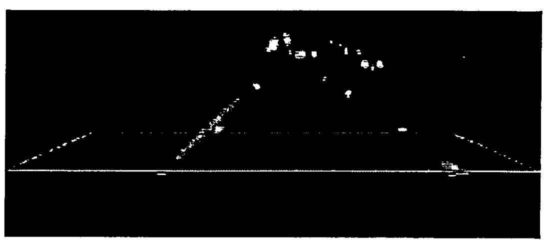

Figure 2: Night driving

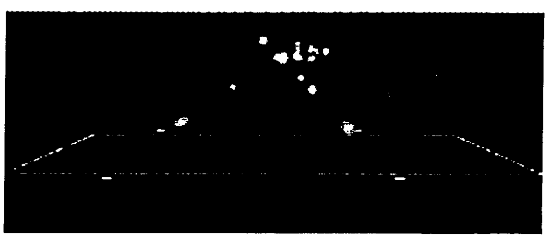

Figure 3: Night driving with only retro-reflectors

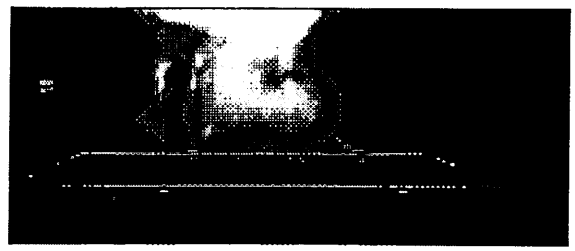

Figure 4: Rain

Figure 5: Snow

Figure 6: No painted lane markings

Applications

In addition to drowsy driver and lane departure warning, the core SafeTRAC technology is well suited for use in other applications. These include video and data logging for accident reconstruction, data collection for performance based safety-incentive programs, and road geometry estimation for use by forward and side collision warning systems.

Availability

SafeTRAC uses a low-cost state-of-the-art DSP that makes it well suited for cost-sensitive OEM applications. It is available both as a complete turnkey system (See Figure 7) as well as a board level solution suitable for OEM integration (See Figure 8). In addition, a research and development version of the system is also available and is well suited for technical evaluation and driving research purposes.

Figure 7: Aftermarket Version of SafeTRAC

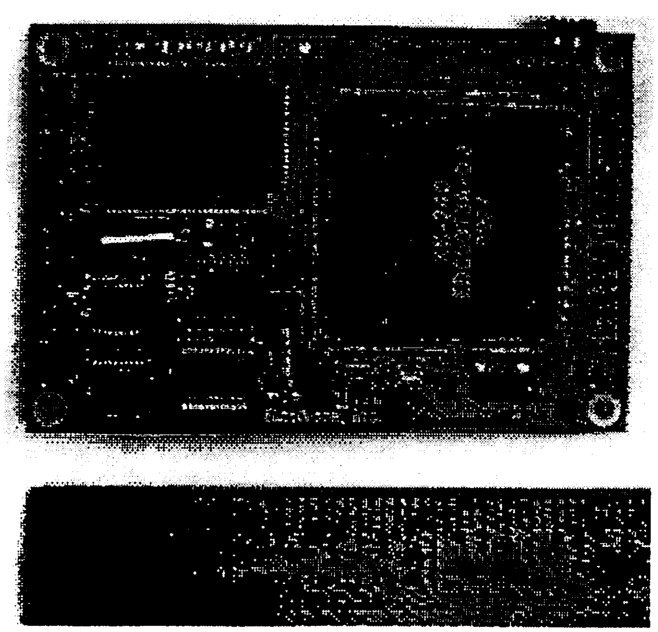

Figure 8: Board level OEM solution

Recommended Practice

Proposed RP 1212 (T) **VMRS 045**

PC TO USER INTERFACE RECOMMENDATIONS FOR ELECTRONIC ENGINES

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TABLE OF CONTENTS

PREFACE

The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Engineering Practices Manual.* Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

1. INTRODUCTION

1.1 PURPOSE

Fleets and dealerships need service tools and software programs that are easy to use and have a common look and feel. Technicians must be able to use electronic engine service tools and software with a high degree of confidence, and training should be simple and fast. Lastly, equipment users and dealerships need common vehicle and operation security. The purpose of this Recommended Practice is to meet these needs by establishing user interface guidelines for the development of service tool software used on commercial vehicles.

This Recommended Practice addresses security, terminology, and functionality standardization. These guidelines should help suppliers provide a similar look and feel to all service software packages, so that technicians are comfortable with both the functionality and location of various tasks within the software, and the terminology used to describe the tools.

1.2 SCOPE

This RP applies to service tools and software packages used to diagnose, program and repair electronic engines used on commercial vehicles.

1.3 OVERVIEW

To achieve commonality, common tasks under common headers must be defined. Passwords should have a set number of minimum and maximum alphanumeric characters. Additionally, previous engine electronic control unit (ECU) changes should record the tool identification and technician logon. Passwords and logons should be placed in a common location under common headers to make the audit trail easy to locate.

1.4 REFERENCES

- TMC RP 1203, *Vehicle Electronics Glossary of Terms.*
- SAE J2403, *Medium/Heavy-Duty Electrical/ Electronic Systems Diagnosis Nomenclature*

2. TERMINOLOGY

2.1 DEFINITION OF TERMS

TMC believes that terminology standardization can be best achieved through adoption of TMC RP 1203 and SAE J2403. Developers are encouraged to use the terminology established in these standards in place of colloquialisms or other terminology currently used by various engine companies and suppliers. In this way, parts specialists, engineers, production and fleet personnel can develop a common understanding of the terminology, thereby reducing miscommunication.

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3. PASSWORD GUIDELINES

3.1 COMMON PASSWORDS FOR USER FUNCTIONS

Passwords for electronic engines today serve the same security function as the mechanical security seals on nonelectronic engines once did. In the past, each mechanical seal carried symbols or wording which helped determine whether an engine's adjustable features had been altered. As with mechanical seals, password protection often cannot identify *who* actually changed the preset engine parameters.

Therefore, the following outline is given as a recommended security system which allows for (1) necessary clearing of codes, (2) reading of parameters, and (3) programming of user functions without jeopardizing the security of a company's established parameters. It also provides an audit trail to determine what parameters were changed and which tool identification was used to make these changes. Once the tool is discovered, the individual who made the changes can be identified—provided the steps outlined in this RP are followed correctly.

3.2 LOGON ID – APPLICATION SOFTWARE

The logon ID and password reside within the application software. They're used to identify individuals either changing parameters or servicing engine ECUs. It should be necessary to enter this logon ID and password prior to opening the diagnostic software program. TMC recommends that there be three levels of passwords:

- System Administrator.
- Supervisor.
- Technician.

A system administrator at the user level would assign the logon ID and password. An example of the System Administrator would be the Director of Maintenance or company designee within the maintenance department.

3.2.1 System Administrator Password

The System Administrator password should allow the System Administrator to use all functions of the diagnostic program and install or remove records pertaining to logon ID's, work orders, programming templates, various engine options and parameters.

The System Administrator must assign the logon ID and password for all users of the system, assign

Supervisor or Technician authority to those users, and determine features within the software that are available to the Supervisor and Technician level. Higher levels of passwords should automatically assume the functions of all lower level passwords.

The System Administrator password should be in possession of the System Administrator and key upper maintenance management only. The System Administrator password should reside in the application software.

3.2.2 Supervisor Password
The Supervisor password should permit all functions of the diagnostic program except the clearing of historical records and the assigning of the various ID passwords. The Supervisor password should not permit the changing of the System Administrator password.

The Supervisor password should permit programmable changes to be accomplished without going back to the System Administrator each time an ECU needs to be updated or reprogrammed. The Supervisor password will reside in the Application Software and will be assigned by the System Administrator.

3.2.3 Technician Password
The Technician password should permit the user to read and clear fault codes, and read diagnostic functions within the diagnostic program. The System Administrator could assign various other duties normally performed at the supervisor level. These assignments would be based upon the technician's abilities and the level of trust that the System Administrator has in the technician. These various levels of abilities should reside within the Application Software and be controlled by the logon password. These options in the application software should match the ECU software. The technician password should reside in the application software. It is imperative, therefore, that when additional duties are assigned to a technician, that the technician must use diagnostic tools that have been configured with his/her logon password and authorized functions.

3.3 USER PASSWORD LOCATION

All application software should begin with a logon screen that requires the user to enter their logon name and their associated password. This allows the user to accomplish all security checks prior to doing any work. If no name/password is entered, the program should function in a "read only" mode and not allow any changes to be made within the ECU. Should the technician decide that changes need to be made after reading the ECU information, he/she should be allowed to go back to the security screen to enter necessary security measures without closing the program.

3.4 ECU PASSWORDS

3.4.1 Customer Password
The ECU should have a Customer password that can be changed by a System Administrator. This password should enable ECU reprogramming, fault code clearing, and ECU record clearing. The Customer password could be the same as the System Administrator password. Access to the various functions allowed by this password should be controlled in the application software according to the level of the logon password, (i.e. Supervisor or Technician).

3.4.2 OEM/Manufacturer Password
This password should not be made available to end users. However, there are certain things about the use of this password that need to be covered in this Recommended Practice. The OEM/Manufacturer password should have access to all functions of the ECU including those assigned as user parameters. Use of this password should be logged and an audit trail of the last three events kept in the ECU.

OEM/Manufacturers should make available to the end user records of any changes to their parameter settings or programming. The issuing of this password to a dealership should automatically initiate a written notice to the end user that the password had been used and program parameters may or may not have been changed. This would require an administration process at the OEM/Manufacturer level to ensure that certain information is gathered before the password is given to the dealership (i.e. Current Owner Information, Speedometer Reading, and Serial Number).

All OEM/Manufacturer passwords should be self-canceling. The method of self-canceling is up to the OEM/Manufacturer.

3.5 Application Software/ECU Password Relationship Overview
To illustrate the envisioned relationship between the Application Software Password and the ECU Passwords, refer to **Figure 1**:

As shown in **Figure 1**, the Application software

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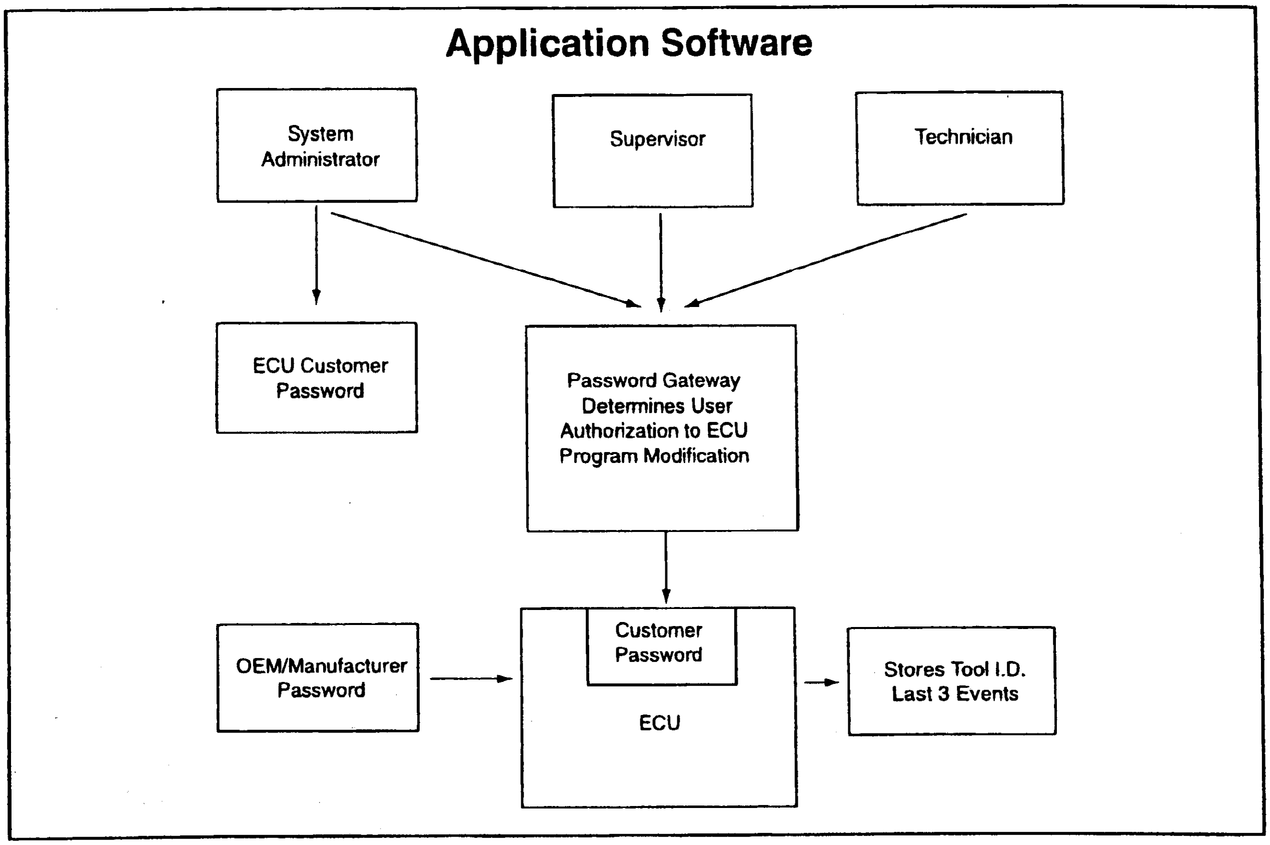

Fig. 1

manages access to the Customer password stored in the ECU. The System Administrator can set or modify the Customer Password in the ECU, as well as create user profiles with various authorities within the core Supervisor and Technician levels of authorization of the system. There is an OEM/Manufacturer password that is not used for general diagnosis, and use of this password should be reported to the end user as described in **Section 3.4.2**.

3.6 Password Specifics

All security passwords should exhibit the following characteristics:

- Alphanumeric only – with no symbols.
- Write to upper case.
- Read to upper and lower case.
- No password will be allowed to be case-specific.
- Passwords should be left-justified
- Fields not used by password should be filled by the application software with ASCII spaces decimal 32, hexadecimal 20. This action will not be observed by the end user.
- Due to global concerns, password field length should be 10 characters.
- The user may enter any number from zero to 10 characters as their password in the application software.
- The manufacturer, while allowing a 10-character entry, would be able to limit the password length by choosing to use any of the characters from four to 10 in number. This limitation should reside in the ECU.

4. SOFTWARE TEMPLATES

The application software should allow the System Administrator to create vehicle templates that contain desired parameters for all similar vehicle ECUs. These templates can then be distributed to the field, allowing programming of several vehicles without direct System Administrator involvement in each vehicle programming event.

5. AUDIT TRAILS

Since diagnostic tools cannot at present communicate with each other—and since these tools are often scattered among different repair facilities—audit trails must reside both in the Application Software and the ECU. The following two sections define the recommendations for each.

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5.1 ECU

Upon an ECU parameter change, the ECU should:

- Store the tool software ID.
- Flag, not maintain, parameter changes:
  - Speed
  - H/P – Torque
  - Customer Settings
- Record the last three software IDs.
- Record date, time and engine hours.

The ECU should maintain these records for the last three ECU programming events.

NOTE: TMC recommends that all vehicle owners replace their ECU security passwords with "0000" at the time the vehicle is removed from service. This should be done in order to preserve your password security and allow the next owner to install their security without the added expense of removing previously installed security measures.

5.2 APPLICATION SOFTWARE

Upon an ECU parameter change, The application software should record the following items:

- Login ID.
- VIN.
- Parameter changes.
- ECU change outs.
- Fault codes at login.
- Fault codes at logoff.
- Event date.
- Engine ID.

The Application Software should be able to store multiple records, the only limitation being the size of the hard drive on the host PC where the Application Software resides.

The Application Software should include maintenance utilities that allow a System Administrator to configure the number of records to be stored on the PC Hard Drive before prompting for a backup of records or purge of the event database. An example would be that the system would maintain the last 150 records, and prompt the user to backup the records to other media (such as floppy disk), at which time the records would be purged from the PC hard disk. It should be noted that the Application Software should never arbitrarily delete records without System Administrator (or Supervisor if the System Administrator has authorized this action at the Supervisor Level) authorization.

6. FUNCTION GROUPING

To reduce confusion among technicians working on various electronic diagnostic programs, software designers should consider common groupings of software functions. This would allow technicians to be proficient in diagnostic software for which they haven't been fully trained. Function grouping would increase shop productivity and reduce misdiagnosis and rework. A flag should be given to technicians in cases where settings of one parameter affect another parameter setting within a different grouping. This flag should tell the technician the parameter being affected and the grouping where it is found.

TMC recommends the following configuration of groupings for cataloguing all features of engine diagnostic software. The functions listed under the groupings should be considered as examples of features within the grouping. The examples should not be considered as the only features within the grouping. It will be up to the individual engine manufacturer and software provider—in conjunction with TMC's VMRS Codes Committee—to determine under which grouping the feature should be listed. TMC recommends that these manufacturers check to see if their feature has already been catalogued into a grouping in order to ensure that the features stay within the same grouping.

6.1 GROUPING CONFIGURATION

6.1.1 Engine Design Configuration

- Engine model.
- Engine serial number.
- ECU serial number.
- Software level.
- Engine horsepower.
- Engine RPM.
- Peak torque.

6.1.2 Fault Codes

- Active.
- Inactive.
- Clear codes.
- Code description.

6.1.3 Vehicle Specs

- Tire RPM.
- Rear axle ratio.
- Top gear ratio.
- Teeth on speed sensor ring.
- VIN number.

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6.1.4 Engine Current Configuration
- Horsepower.
- Torque.
- Maximum RPM.
- Idle speed.

6.1.5 Management Reports
- Trip data.
- Engine hours.
- Total gallons.
- Idle hours.
- Idle fuel.
- Graphs.

6.1.6 Driver Controlled Features

6.1.7 Test
- Cylinder cutout.
- Response times.
- Calibration.
- Hydrocarbon test.

6.1.8 Management Controlled Features
- Driver incentive.
- Driver password.
- Co-Driver password.
- Theft deterrent.
- Engine start/shutdown.

7.0 INCIDENT EVENTS DATA
This category is to be used for information gathered during an event. The information, once logged into this category, should only be accessed by the use of a special password. This password should be different from all fleet or OEM passwords and must reside within the ECU. This allows the use of any diagnostic tool with the proper programming to access the information by using the proper password. This password should be assigned by the System Administrator. Anyone wishing to access information contained in this incident event category must first obtain the password from the system administrator. Refer to **Section 3.6** for password specifications.

Incident events data might include the following:
- Battery voltage.
- Engine throttle status.
- Engine RPM.
- Vehicle mileage.
- Vehicle ID number.
- Vehicle speed.
- Time and date.
- Deceleration rate.

NOTE: TMC does not intend that any of the items listed above should be placed in the incident event category. They are merely examples of what might be found in this category.

Only engine manufacturers possess all of this information on their products and, because gathering procedures may differ between models, engine manufacturers must be involved in determining whether the data is pertinent to the incidents being investigated. It should be up to engine manufacturers to decide what data will be stored in this category.

The information contained in this category will retain the last three incidents for each event category in order to ensure that all available ECU information needed to aid in incident reconstruction is recorded. Due to the need of having information from other ECUs on the vehicle, all information should be obtained through the datalink supplied by the OEM. This permits access of all ECU incident event data. Use of data contained within the engine ECU may not supply the data needed to get an accurate picture of the events that occurred during an incident. Therefore, TMC recommends that all ECUs be polled for the incident event data before any conclusions are made concerning incidents.

Crash Survivable Module

For

Trucks and Busses

BACKGROUND

SI-IMS is the Information Management Systems Division of Smiths Industries, Plc. This division is headquartered in Grand Rapids, Michigan.

We are an established developer and manufacturer of aerospace products with over 50 years of manufacturing experience. These products include digital and analog systems for navigation, weapon delivery, guidance and control, and aircraft performance management and recording. Our systems are on fighter and multi-engine aircraft, drones, missiles, launching platforms, helicopters, RPVs, radar subsystems, ships, space vehicles, tanks, and torpedoes.

SI-IMS is a world leader in the design, development, and production of solid-state crash survivable flight data recorder systems. Starting in 1984 with the competitively awarded Crash Survivable Flight Data Recorder (CSFDR) for the F-16 *"Fighting Falcon,"* through the sole source derivative, the U S Air Force (USAF) Standard Flight Data Recorder (SFDR), to our latest data recorder systems - the combined Voice and Data Recorder (VADR®), the Integrated Data Acquisition Recorder (IDAR) the Health Usage Monitoring System (HUMS), and the Voyage Data Recorder (VDR) for ocean going vessels, SI-IMS has continuously expanded and made improvements to the initial recorder systems. The Grand Rapids site, which has developed and produced these recorder products and systems, employs approximately 1,000 people, including more than 600 professional technical personnel.

CRASH SURVIVABLE RECORDER FOR TRUCKS AND BUSSES

Whether the vehicle is an aircraft, ship, spacecraft, or ground vehicle, the crash survivability specification should be derived from the crash environment that the vehicle is likely to encounter in an actual mishap. Crash survivable recorder design history tells us that the sequence of events during an actual mishap can be

- Impact shock
- General shock
- Penetration (punch through)
- Static crush (deadweight)
- Fire, and
- Water immersion.

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These are the parameters to which the Crash Survivable Module (CSM) must be tested. Our initial determination of values for these parameters, as they relate to trucks and busses, is presented in the following section.

As in the case of other types of vehicles, a determination must be made of the truck and bus parameters that need to be recorded in order to reconstruct the accident profile via a dedicated software package. This permits an analysis of the mishap and determination of the causal factors. Our initial determination of parameters that need to be recorded, as they relate to truck and bus mishaps, is also presented in the following section.

CRASH ENVIRONMENT AND PARAMETERS NEEDED FOR TRUCKS AND BUSSES

Survivability parameters follow a logical sequence of events resulting from a crash for any type of vehicle. For an aircraft, the initiating event is the impact of the airframe with the earth's surface. Two scenarios can follow at this point; a land impact or a water impact. The survivability parameters are specified in order of occurrence and must also be tested in that order. For an aircraft these are:

1. Deceleration: 3400 G's with a time duration of 6.5 Milliseconds. This represents the initial impact. The test is required to be in the direction to which the CSM is most at risk for damage.

2. Penetration: A ¼" diameter pin driven by a 500 pound weight dropped from a height of 10 feet. This represents debris following the CSM into the impact, which is driven by the mass of other portions of the aircraft. The pin represents a bolt or sheared structural member, but may be any sharp corner or edge of the debris. The test is applied to 3 mutually perpendicular faces of the CSM.

3. Static crush: A dead weight of 5000 pounds is applied diagonally across each of the 3 major axes of the CSM for a period of 5 minutes. This represents a major aircraft element, such as an engine core, resting on the CSM.

At this point, the standard differentiates between a land impact and a water impact.

4. For a land impact, the next test is a high intensity fire. The standard requires a 1-hour exposure to a fire with a flame temperature of 1100 degrees C having an intensity of 50,000 BTU/Hour. This represents the fire from aircraft on-board fuel.

5. The final land impact test is a 10 hour, 260 Degree C, low intensity fire. This test is required because both high and low intensity fires have been experienced in actual aircraft crashes.

A water impact does not require the fire, but instead substitutes a 30-day seawater soak at a pressure equivalent to a depth of 20,000 feet. The standard does not require that the CSM assembly be watertight if it can be shown that the storage media is immune to the salt water and pressure exposure.

CSM survivability for trucks and busses

In general, the sequence of events described for aircraft will also apply to truck and bus mishaps. The differences in the requirements will be in the magnitude of those requirements. A proposed set of test levels and the rationale for those levels follows. They are presented with the aircraft level requirements for comparison.

Crash Impact Requirements Comparison

Parameter	Airborne (ED-56A)	Trucks/Busses
Impact shock	3400 G, 6.5 m Sec	300 G, 50 m Sec
Penetration	0.25" pin, 500 Lb, 10 ft	0.50" pin, 200 Lb, 3 ft
Deadweight	5000 Lb on diagonals	500 Lb on diagonals
High Level Fire	1100 Deg. C., 1 hour	900 Deg. C., 20 min
Low Level Fire	260 Deg. C., 10 hours	260 Deg. C., 5 hours
Water soak	20,000 FT, 30 days	100 FT, 10 days

Impact shock: Information supplied by General Motors and based on their testing of large trucks indicates that a truck traveling at 35 MPH and hitting a solid barrier will experience about 40 G's for a period of 50 milliseconds inside the cab. Extrapolating this to a speed of 70 MPH gives a value of 160 G's. Since this may represent more of an average or nominal value, it is doubled to get to a worst case scenario.

Penetration: Changed to represent lower total mass drivers, shorter distances, and a penetration pin size that is closer to the components found in a truck structure.

Deadweight: This number is reduced to 500 pounds, a value that represents singular high mass elements of the vehicle such as the engine/transmission or an axle/differential assembly.

High Level Fire: The intensity is reduced slightly. The aircraft based requirement assumes accelerants such as oxygen from crew or passenger breathing systems and/or structural elements of magnesium, neither of which are common in trucks or busses. The time interval of the fire is reduced, recognizing that substantially less fuel is on board.

Low Level Fire: The time duration is reduced but not the intensity. The post high level burnout condition and cool down will likely behave in a manner similar to an aircraft fire but without the total mass in the wreckage that an aircraft would have.

Water immersion: Both depth and time duration are reduced. Truck or bus wreckage into water is extremely unlikely to involve deep water or to be undetectable and remain there for any long period of time.

The analysis above does not take into consideration any cargo that may be present in trailers or the cargo section of a truck. As it affects the survivability of a CSM, the cargo can be examined in three categories. They are:

1. Total mass. This affects the CSM survivability from the standpoint of crush resistance and may contribute to extend the low temperature fire duration. Examples of this are: lumber and building products, brick and concrete.
2. Density. This affects the penetration resistance and, in combination with total mass, further affects crush resistance. Examples are: Steel plate, rod, bar, pipe, or other metal stock.
3. Flammability. This affects high temperature fire duration. Examples are propane or gasoline.

If the cargo is the right type or is large enough, the CSM survivability parameters begin to approach the aircraft levels with the exception of the impact shock. An additional issue for tractor-trailer vehicle configurations is the behavior of the cargo at the time of impact. If the incident is a straight-line event, the cargo certainly becomes part of the survivability consideration. If, however, the impact includes a rotational component (jackknife), then the cargo passes by the CSM portion of the crash event and does not interact or add to the CSM survivability issue. The degree of cargo interaction with a crash event is a subject for future study.

It should be recognized that no specification can provide a definition of a true "worst case" scenario without reaching very large magnitudes for survivability requirements. The aviation based requirements still come up short for some crash events. A level of information recovery from a crash event of slightly less than 100% can be expected for a cost-effective design.

Vehicle data recording

The selection of parameters which can be used to reconstruct an incident are in 3 major categories. They are:

1. Operator commands and control inputs
2. Vehicle responses and actions
3. Environmental information

Operator commands and control inputs

1 Steering
2. Braking
3. Accelerator
4. Warning signals (horn, lights)
5. Transmission

Vehicle responses and actions

1. Speed
2. Acceleration components (X and Y)
3. Radar forward and side closing rates (if available)
4. Braking response
5. Engine speed and response
6. Other vehicle and engine status

Environmental information

1. Temperature
2. Vehicle location (if GPS equipped)
3. Other weather related.
4. Ambient lighting

These parameters can be collected by suitable on-board electronics and stored in a CSM. The tabular list which follows, identifies the parameter, accuracy required, and data rate at which the parameter should be collected and stored.

Operator commands and control inputs

Parameter	Range	Accuracy	Update Rate (HZ)	Bits	Total Bit Rate
Steering wheel	3600 degrees	1 degree	10	13	130
Throttle position	0-100%	10%	5	4	20
Brake petal pressure	0-100%	10%	5	4	20
Air brake pressure	0-200 PSI	20 PSI	5	4	20
Horn	Binary		5	1	5
			TOTAL BITS/SEC		195

Vehicle responses and actions

Parameter	Range	Accuracy	Update Rate (HZ)	Bits	Total Bit Rate
Vehicle speed	0-100 MPH	1 MPH	5	7	35
Engine speed	0-4000 RPM	100 RPM	5	9	45
Transmission gear	1-20	1	1	5	5
Engine (Note 1)	as needed	10%	1	32	32
Warnings (Note 1)	Binary		1	8	8
Forward radar	0-200 FT	1 FT	5	8	40
Left radar	0-200 FT	1 FT	5	8	40
Right Radar	0-200 FT	1 FT	5	8	40
X,Y acceleration	+/- 2 G	20 mG	10	20	200
			TOTAL BITS/SEC		445

Environmental Information

Parameter	Range	Accuracy	Update Rate (HZ)	Bits	Total Bit Rate
Temperature	-20/+120 Deg. F.	5 Deg F.	1	5	5
Location (GPS)	Global (segmented)	100 meters	1	32	32
Other (note 1)	As appropriate	5%	1	10	10
			TOTAL BITS/SEC		47

Note 1: Multiple parameters can be packed and multiplexed into the same storage word at a low effective data rate.

CRASH SURVIVABLE MODULE INTERFACING

The CSM is not, by itself, a functional element. It needs support from a microprocessor to provide low level management of data from a sensor suite. The data must be formatted to fit the structure of the CSM. Management overhead of the CSM includes erasing blocks of memory in advance of the need to write to them, determination of how the data maps to the physical structure of the memory, and in the case of event flagging, managing the continuous data recording function while maintaining the flag event data separately. The CSM may be hosted in a larger system, or may be a stand-alone function. Some tradeoffs are:

1: Smart Interface - RS-232 or RS-422 at 9600 baud

Advantages:

Stand-alone module.
Can be located anywhere in vehicle.
Manages low-level protocols into and from hardened storage element. (CSM)
Changes and upgrades do not affect core systems.
Download and recovery can be independent of core systems.

Disadvantages:

Requires enclosure and power source.
Requires cabling.

2: Imbedded CSM storage element only.

Advantages:

Integrated into other electronics, no separate enclosure.

Disadvantages:

System integrator must implement low level interface protocol in his processor.
Physical location may not be optimal for survivability.
May require higher level processing and/or a more complex microcomputer to handle the additional task load.

SUMMARY

The technology is available to make on-board recorders crash survivable for trucks and busses. A preliminary crash survivability specification has been developed by using procedures similar to those of the aircraft industry. With the state-of-the-art of the recorder industry, it is possible to design and produce a low-cost CSM that will hold the necessary parameters for mishap reconstruction via a dedicated ground support software package. We recommend that the Department of Transportation require that future on-board recorders, for trucks and busses, be designed to meet crash survivability standards.

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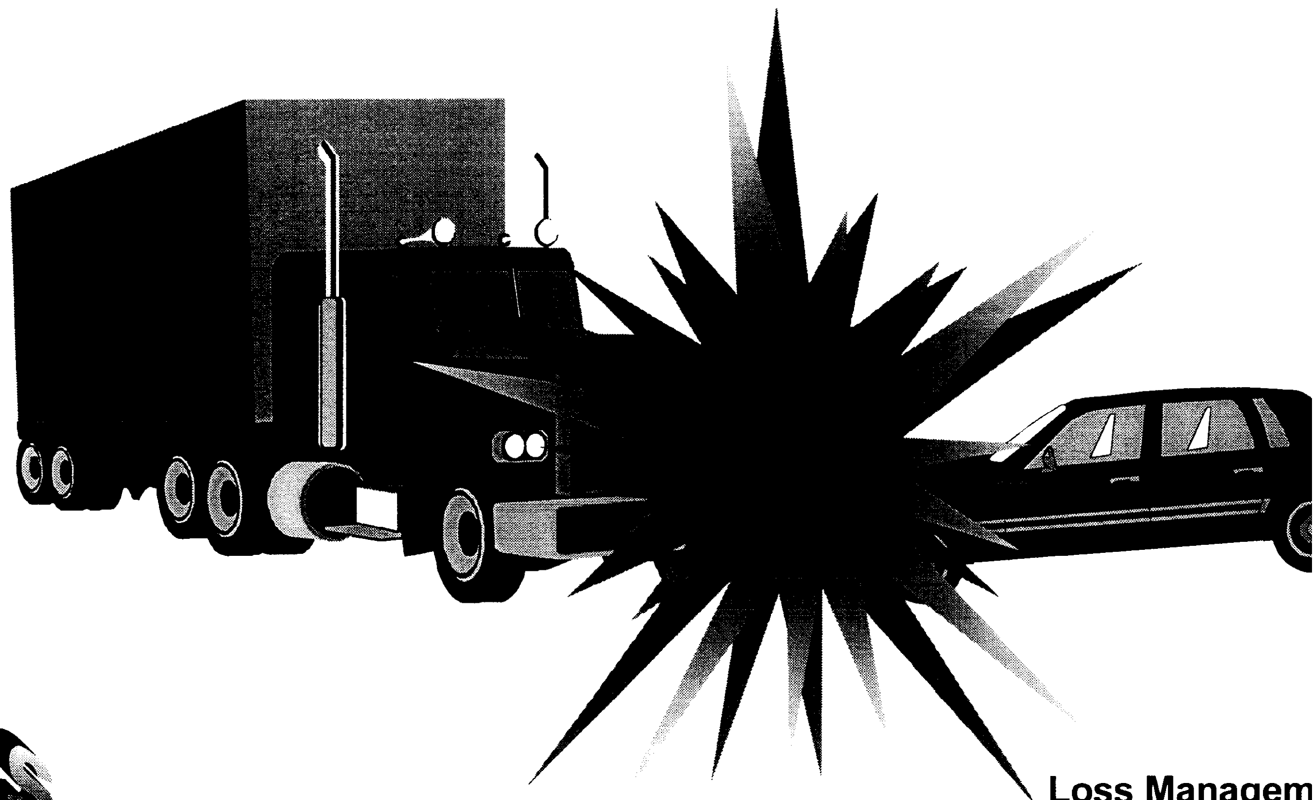

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MACBOX ™
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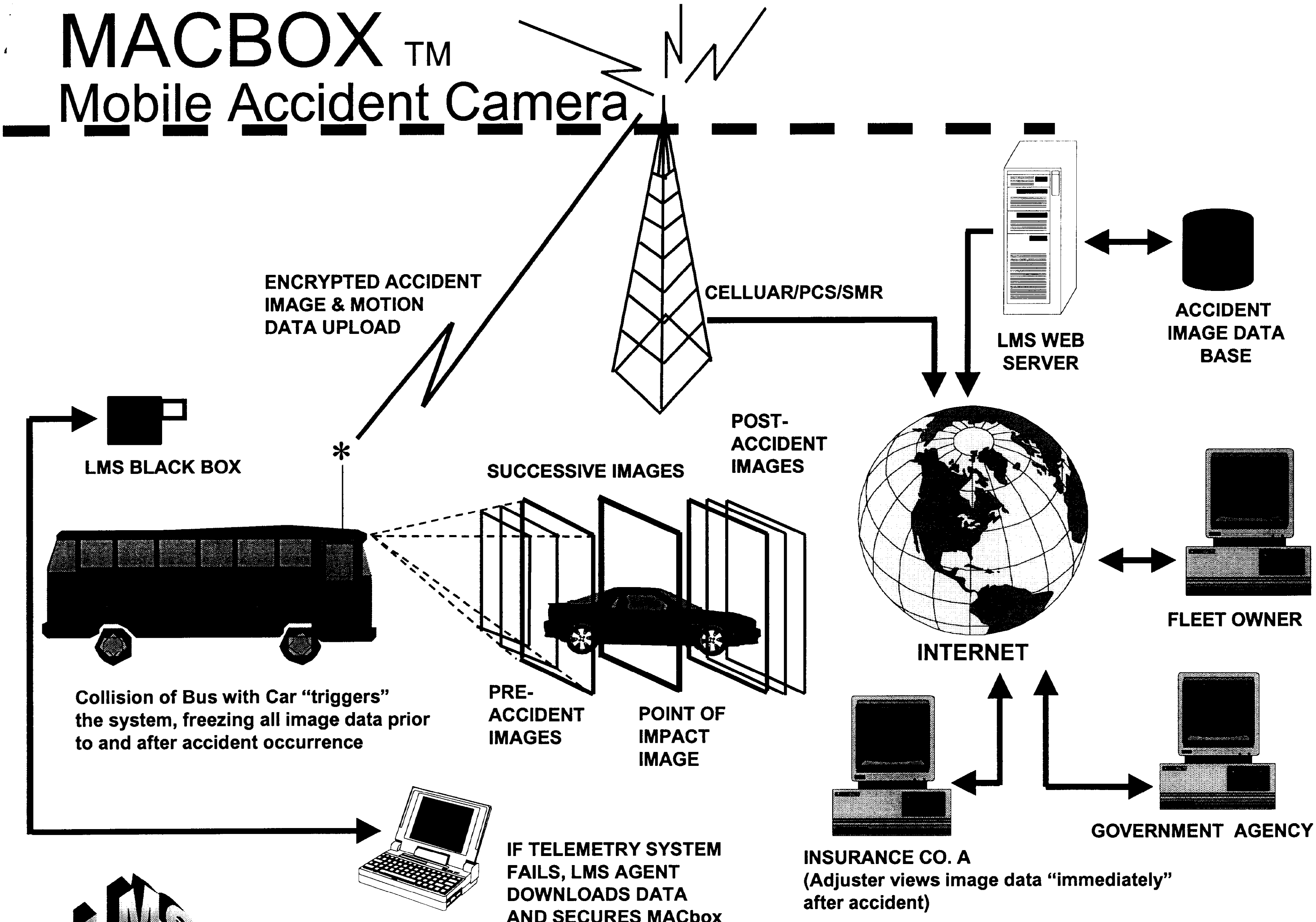

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